

A Review of Myxosporea, Microspora and Monogenea Infections in African Fish

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Abstract: Myxosporea, Microspora and Monogenea infections in African fish was reviewed to educate fish culturists on some potential challenges in culture fisheries management. The description, taxonomy and diagnosis, Pathology, Life cycle and biology, Epizootiology and Control of Myxosporea, Microspora and Monogenea in African fish was reviewed to educate fish culturist on more challenges faced in culture fisheries. Myxosporidia is a class of protozoa which parasitize invertebrates and lower vertebrates particularly fish, often fatal consequences for the host. Microspora consists of simpler spores and are of unicellular origin. They occur in animals of most phyla, but are most commonly found in insects and fishes, where they multiply in the host cells and cause hypertrophy of host tissues. Monogenea is a class of the phylum platyhelminthes commonly found on the skin and gills of marine and fresh water fishes. The worms are characterized by an opisthaptor. The life cycle is Monoxenous. They are hermaphrodites and mainly ectoparasites though a few are known to be endoparasites. These parasites are problem to culture fisheries causing fish mortality.

Key words: African fish, infections, microspora, monogenea, myxosporea

INTRODUCTION

Myxosporidia is a class of protozoa which parasitize invertebrates and lower vertebrates particularly fish, often fatal consequences for the host (Bassey, 2011). They are formed from several cells during sporulation. And there are some doubts that they are really protozoan. Microspora consists of simpler spores and are of unicellular origin. They occur in animals of most phyla, but are most commonly found in insects and fishes, where they multiply in the host cells and cause hypertrophy of host tissue (Bassey, 2011). The best known microsporidian diseases are caused by species of *Nosema*, which parasitize intestinal cells of honey bees and other insects. The Haplosporea are parasites of the invertebrates and fish and are probably related to microsporidians although they lack polar filaments. Monogenea is a class of the phylum platyhelminthes commonly found on the skin and gills of marine and fresh water fishes. The worms are characterized by living a posterior attachment, the opisthaptor, which is armed with hooks and/or suckers and sticky glands in the proaptor at the end. The life cycle is direct (there is no intermediate host) (Monoxenous). They are hermaphrodites and mainly ectoparasites though a few are known to be endoparasites (Bassey, 2011).

Representative of many fish families, very common in Cichlidae, Cyprinidae and in brackish waters in

Mugilidae. Data beyond single species descriptions are available from Egypt (Fahmy *et al.*, 1975), East Africa (Baker, 1963; Paperna, 1973), Ghana (Paperna, 1968a, b, 1973), the Cameroons and Israel (in cichlids and *Clarias lazera* Landsberg, 1985, 1986). In some of these reports differentiation to species is lacking or incomplete (Paperna, 1968a, b, 1973; Fahmy *et al.*, 1975). Infections by *Myxobolus*, *Thelohanellus* and *Henneguya* occur in both East African and West African waters. They are apparently host specific and as widespread as their respective hosts. Ovarian infections of cichlids are thus far known from the Great Lakes, *Haplochromis* spp. (Paperna, 1973).

Thus far, only reported in cichlids from Africa and the Near East. Microsporidian infection has been described from many Holarctic marine and freshwater fish. There are very few reports of infections in fish in the tropics. Microsporidian infections were reported from Lake George, East Africa (Swimbladder of *Haplochromis* spp.) (Paperna, 1973) and in the Republic of Benin (in gills and viscera of *Tilapia* and *Sarotherodon* spp.) (Sakiti and Bouix, 1987). Microsporidian spores were also detected in kidneys of *Oreochromis aureus* and its hybrids, in Israel. Plistophora (syn. Pleistophora) infection has been reported from glass eels and elvers in the Umtata and Keiskama rivers in Transkei (southern Africa) (Jackson, 1978).

Fresh water and brackish water fish from most families of Teleostei (Khalil, 1971; Paperna, 1979). Present in all inland waters of Africa. Species, and often also genera, of Monogenea demonstrate a high degree of host specificity, and follow their respective specific fish hosts throughout their distribution range. African species of Monogenea of *Clarias* spp. and of Cichlidae occur on hosts from the same families present in the Near East. Cichlid monogeneans, including the endoparasitic *Enterogyrus cichlidarum* of *Oreochromis niloticus* and *O. mossambicus*, were introduced with their hosts to Southeast Asia (Natividad *et al.*, 1986; Bondad-Reantaso and Arthur, 1990). On the other hand, exotic monogeneans were introduced with their specific hosts into Africa; *Dactylogyrus minutus*, *D. anchoratus* and *Pseudoacolpenteron pavlovskii* with carp (Paperna, 1980) and *Acolpenteron ureteroecetes* with the American large mouth bass *Micropterus salmoides* (Du Plessis, 1948). The Description, taxonomy and diagnosis, Pathology, Life cycle and biology, Epizootiology and Control of Myxosporea, Microspora and Monogenea in African fish was reviewed to educate fish culturist on more challenges faced in culture fisheries.

Myxosporea:

Description taxonomy and diagnosis: Myxosporea cause histozoic (e.g. in tissue) and coelozoic (in internal cavities e.g. in gall and urinary bladders) infections. Gross signs of histozoic infection are whitish cysts with a milky substance containing microscopic (5-5 µm longer axis) spores. Large cysts are readily traced, small cysts in tissues, inside viscera and connective tissue and muscles, are detectable when tissue samples are pressed between slides, or in histological material. Spores are readily detected in aqueous methylene blue-stained smears. The so called cyst is a parasite-origin plasmodium which forms a specialised membranous junction of pinocytotic vesicles (canals) with the surrounding host cells (Current and Janovy, 1976).

Spores, hard-walled, with one to six polar capsules are differentiated by sporogenesis within the plasmodium. The polar capsule contains a coiled filament which may be extruded under pressure or other stimulants, including fixation with absolute methanol. Coelozoic myxosporea of the urinary and bile cavities have a small plasmodium and produce few spores, often only two. Premature plasmodia are attached by pseudopodia to the epithelial lining of the bladder (Paperna *et al.*, 1987). Small diplosporid plasmodia (“pseudoplasmodia”) are characteristic of *Myxidium* and *Sphaerospora* which develop from within the kidney tubule into the lumen (Dykova and Lom, 1982) and also in the gut lamina propria (Diamant, 1992).

Genera are identified by spore configuration. Diagnosis to species level is based mainly on

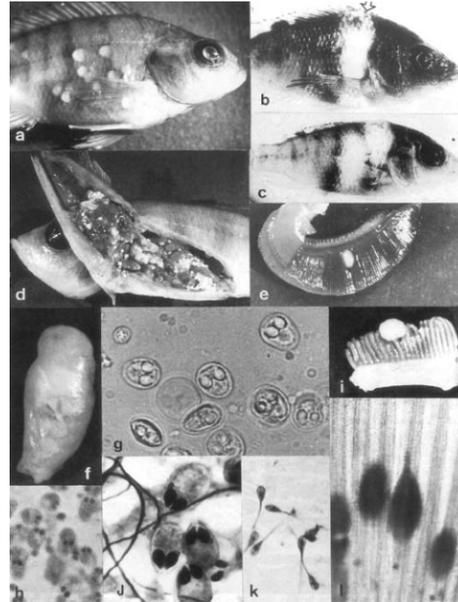


Plate 1: Myxosporea Source: docrep_redirector_head_ache_data

measurements of fresh unfixed spores, their polar capsule dimensions as well as the length of the extruded polar filament (Lom and Arthur, 1989). Separation of the genus *Myxosoma* from *Myxobolus* by the presence or absence of a iodophilus vacuole does not appear to be taxonomically valid (Walliker, 1968). Ultrastructural studies (scanning) demonstrate interspecific and intergeneric variation in the surface configuration (which consists of 1–6 valves joined by sutures) (Lom & Hoffman, 1971). Location of the cysts/plasmodia in the host may be of diagnostic value in site specific species, while others are not fastidious in their site preferences.

Plate 1. Shows Myxosporea: a. *Myxobolus* cysts beneath scales of *Oreochromis variabilis* from northern Lake Victoria (× 4.0). b,c. *Tilapia* spp. from a fish pond in Malawi with one (arrow) or two large transverse myxosporean (reported as *Myxobolus*) cysts. d. Myxosporean cysts in viscera of *Haplochromis* sp. from L. Edward. e. Cyst of *Myxobolus unicapsulatus* on gills of *Labeo cubie* from northern L. Victoria (× 2.8). f. Ovary of *H. angustifrons* from L. George, hypertrophic due to *Myxobolus* infection (× 2.8). g. *Myxobolus* spores from visceral cysts of *Haplochromis* sp. (× 1400) (fig. d). h. *Myxobolus* cysts from *H. angustifrons* ovary (× 700) (fig. f). i. *Myxobolus* cyst on gills of *Heterotis niloticus* from Landja, Central African Republic (Coll. by J.C. Micna) (× 2.8). j. *Myxobolus* sp. spores from large dermal cysts from young *Oreochromis niloticus* from Kisumu bay, Lake Victoria. k,l. *Henneguya* sp. spores from cysts on gills of *Lates niloticus* from northern Lake Victoria. Life cycle and biology.

The life histories of myxosporeans in African fish are not known. It has been shown that transmission of *Myxosoma cerebralis* of trout and several other myxosporean parasites of other fish involves tubificid oligochaetes as intermediate hosts (Wolf and Markiw, 1984; El Matbuli and Hoffmann, 1989). Goldfish became infected with *Myxobolus*, *Zchokkella* and *Thelohanellus* after being fed on tubificids infected by actinosporeans (Yokoyama *et al.*, 1991). It has also been demonstrated that an early migratory proliferative phase precedes later sporulating plasmodia in tissues or, of *Sphaerospora*, in the kidneys (Lom and Dykova, 1986) or the gills (Lom *et al.*, 1983). Such dividing plasmodia occur in blood (Csaba or C - bodies) and in the swimbladder tissue (Korting, 1982; Csaba *et al.*, 1984; Molnar and Kovacs-Geyer, 1986) in carp and in the kidney haematopoietic tissue of trout (PKX cells, Kent and Hedrick, 1985).

Myxosporean multinucleate formations preceding spore formation are generated by endogenous divisions, where cells are formed within cells. This process occurs in the early proliferative stages and during the process of sporogenesis. Primary cells from the plasmodia generate, by endogenous division, secondary inner cells which further divide by mitosis. Their progeny (the sporogenic cells) produce, by endogenesis, tertiary cells within them. The sequences of divisions which lead to spore formation also include meiotic division (Lom and Dykova, 1986). The spore is formed from enveloping (pericytes) and inner cells transforming into shell valves, polar capsules and to sporoplasm. Spores of coelozoic forms are evacuated with the bile and the urine. Cysts in the skin, gills, and the digestive tract release spores by rupture. In grey mullets, entire cysts in the digestive tract wall are discharged into the gut lumen in the form of a white ball. The only other alternative for the release of myxosporean spores is after their host's death.

Pathology: Several myxosporean infections of cultured fish were reported to be pathogenic. Most notorious is the whirling disease of trout, manifested by skeletal deformities, which is also claimed to have been introduced with rainbow trout into South Africa (Van Wyk, 1968). In farmed carp, *Myxobolus* spp. caused locomotory disturbances coupled with emaciation, and sunken eyes in brain infections (Dykova *et al.*, 1986), anaemia and haemorrhagic dropsy and mortality in a heavy cardiac infection (Bauer *et al.*, 1991) and circulatory disfunctions in infections at the bases of the gill lamellae (Kovac-Geyer and Molnar, 1983). Heavy infection of carp gills with *M. koi* caused fusion through epithelial hypertrophy, and congestion; rupture of cysts caused inflammation. Damage to the gills by dense infestation resulted in respiratory problems; fish were swimming near the surface with distended operculi (Rukyani, 1990). Severe disaggregation of the respiratory

epithelium is caused by *Sphaerospora* spp. infections of carp and goldfish gills (Lom *et al.*, 1983).

Several myxosporeans cause renal pathology in carp and goldfish: *Sphaerospora renicola* proliferating in the renal tubules damages the renal tubuli epithelium and the released spores congest excretory passages (Dykova and Lom, 1982). Presporulating forms named *Hofferellus*, with a postulated identity with species of *Mitraspora* (Molnar *et al.*, 1986), cause Kidney Enlargement Disease by infecting the epithelial cells of the renal tubules (Yokoyama *et al.*, 1990). Proliferative stages of *Sphaerospora* cause proliferative hypertrophy of the kidney in salmonids (Kent and Hedrick, 1985) and grey mullets (Paperna, 1991). Proliferative, presporulating stages of *Sphaerospora renicola* were demonstrated to be the aetiological cause of swimbladder inflammation in carp (Korting, 1982; Csaba *et al.*, 1984; Molnar and Kovacs-Geyer, 1986).

Cysts of histozoic myxosporidians provoke inflammation only after their disintegration, and in most instances it is when myxosporan infections become pathogenic to their host and cause clinical conditions (examples: gill infections of American catfish with *Henneguya exilis* - McCraren *et al.*, 1975; *Channa punctata* with *Henneguya waltirensis* - Kalavati & Narasimhamurti, 1985; and carp with *Myxobolus koi* - Rukyani, 1990). Rupture of cysts also leads to haemorrhaging, sometimes resulting in considerable loss of blood (Kalavati & Narasimhamurti, 1985).

In some infections, host response may lead to tumour-like proliferations incorporating parasite plasmodia and the capillary net-work (Nigrelli and Smith, 1938). Rupture of dermal and branchial cysts caused intense haemorrhaging and facilitated invasion of secondary opportunistic pathogens (Paperna and Overstreet, 1981). In fish in Africa, histozoic myxosporidians occur as skin infections, with cysts formed in the dermis, under the scales, extending to the surface of the head (face, lips) or onto the fins (*Myxobolus* spp. in juvenile cichlids, *Henneguya laterocapsulata* in *Clarias lazera*), and in the gill filaments (*Myxobolus* spp. in Cyprinidae, siluroids, Characidae, *Distichodus rostratus*, *Heterotis niloticus*; *Thelohanellus* in cyprinids and *Henneguya* in *Lates albertianus* as well as in citharinids, cyprinids and siluroids) (Paperna, 1973; Abolarin, 1974; Landsberg, 1986). *Myxobolus* cysts occur in the pharyngo-branchial cavity (of *Ctenopoma* spp.), the interior organs, muscles and viscera. Such infections are best known from cichlids, but also occur in fish from other families (Paperna, 1973). *Sphaerospora* occur in kidneys of *Clarias lazera* (Landsberg, 1986) and Grey mullets (Paperna, 1991).

Infections (even heavy infections) often occur in fish otherwise in good condition. Nonetheless, multiple cysts and particularly large cysts in vulnerable organs such as

the gills, may compromise fish health. Large *Myxobolus* cysts caused body deformity or curvature of *Barbus lineatus* and cichlids (Paperna and Thurston, 1968). Ovarian infection in female cichlids from L. Victoria remained focal in the interstitial tissue, while that (a different species) occurring in cichlids (*Haplochromis angustifrons* and *H. elegans*) from L. George enlarged the ovary while displacing the entire ovigerous tissue, evidently causing castration. The only reported coelozoic infection in freshwater African fish is that of *Myxidium clariae* from *C. lazera* gall bladder (Landsberg, 1986). Rupture of mature cysts leads to host-tissue responses as well as phagocytosis of spores and their capsule residues. Spores accumulate in melanomacrophage centres in the kidney and the spleen (Ogawa *et al.*, 1992). Spores encountered in the spleen are therefore residues of past infections elsewhere (Baker, 1963; Landsberg, 1985).

Epizootiology: Prevalence of infection is variable. In the East African Lakes visceral *Myxobolus* infections in *Oreochromis* were very prevalent (89–100%), while in *Haplochromis* spp. they were only exceptionally above 25%. Skin and gill infections in juvenile as well as larger cichlids are also not too prevalent, although very heavily infected individuals were collected. Infection levels seem to change with time (Fryer, 1961; Baker, 1963; Paperna, 1973). Gill infection (*Myxobolus*, *Thelohanellus* and *Henneburya*) of cyprinid fish and siluroids seems to be very common in Lake Volta, in the Ruaha river, Tanzania, and in the Cameroons, but quantitative data are limited (Paperna, 1968a, b; Fomena *et al.*, 1984/5), or non-existent (Paperna, 1973). Epizootic infection has been reported in grey mullets farmed in freshwater ponds in Israel (Sarig, 1971).

Ovarian infections, leading to castration in *Haplochromis* spp., occurred in less than 4% of female fish, and only in L. George. In L. Victoria only the mild ovo-mesenteric infection occurred. Neither in Israel, where tilapia are intensively farmed, nor elsewhere in Africa, has the epizootic form of infection ever been observed, except in one farm in Malawi where fish developed large subdermal deforming cysts. Detailed information on this case is, however, lacking. Of all pathogenic myxosporeans reported in carp or goldfish none have thus far been reported in carp farmed in Africa despite the fact that swimbladder inflammation and kidney infections with *Sphaerospora renicola* occur in carp reared in Israel (Landsberg, 1989). The carp gill infecting *Myxobolus koi* has been recently recovered on goldfish stock imported to Israel from China.

Control: To this day no readily effective and easy-to-use drug is available to treat myxosporean infections. Trials with Fumagillin (also used to control microsporidial infections) produced encouraging results but at the same

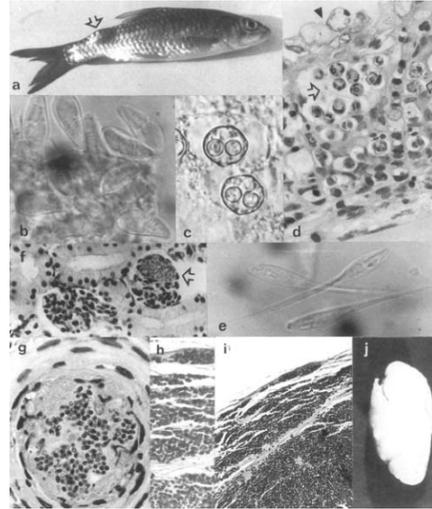


Plate 2: Myxosporea continued and microspora Source: *docrep_redirector_head_cache_data*

time the tolerance of the fish to therapeutic doses was variable and some workers reported side effects of intoxication following treatment schedules (Sitja-Bobadilla and Alvares-Pelleteiro, 1992; Molnar, 1993). Sphaerosporosis of trout (PKD) and carp, and *Dicentrarchus labrax*, hoferellosis of goldfish and trout whirling disease were treated with medicated food containing 0.5–1 g Fumagillin kg⁻¹ fed at 1.5% body weight (or 0.5–1 g kg⁻¹ fish body mass) for 7–8 weeks (Hedrick *et al.*, 1988; Yokoyama *et al.*, 1990; El Matbouli & Hoffmann, 1991; Sitja-Bobadilla and Alvares-Pelleteiro, 1992; Molnar, 1993). Fumagillin when applied to *Myxidium giardi* infected elvers arrested development but failed to eliminate the parasite which resumed development when medication was ended (Szekely *et al.*, 1988). The cost of Fumagillin, is however, economically prohibitive for use in food-fish farming (tilapia, catfish and carp). The efficacy of other tested drugs such as furazolidon and toltrazuril remains inconclusive (Yokoyama *et al.*, 1990; Molnar, 1993).

Microspora:

Description, taxonomy and diagnosis: Microsporidia are obligate intracellular parasites. Infected cells usually enlarge to accommodate the proliferating parasite. Such enlarged cells are termed xenomas. Within these xenomas, parasites undergo merogonous and sporogonous development which culminates in the production of spores (Canning and Lom, 1986; Lom and Dykova, 1992). The spores are thick walled and contain a characteristic coiled polar filament and one (Pleistophorida) or two nuclei (Nosematidida) (Weiser, 1985). Infection is readily detectable by the presence of spores in tissue smears (fresh or Giemsa stained), or in histological section.

Hypertrophic infected cells may reach macroscopic sizes and often yield characteristic gross pathological signs; multiple whitish nodules in tissues, or in case of the swimbladder, a significant thickening of the walls. Differentiation from other aetiological agents, inducing cellular hypertrophy (Lymphocystis, Epitheliocystis and Myxosporaea), is achieved by demonstration of spores in such tissues.

Generic and specific differentiation is often aided by ultrastructural data (Canning and Lom, 1986). Keys for generic differentiation were prepared by Weiser (1985).

Plate 2 shows Myxosporaea continued and Microspora: a. Subdermal node due to *Myxobolus* in *Barbus (Tor) canis* from L. Kinneret, Israel. b. Spores of *Thelohanellus* sp. from cysts on gills of *Labeo senegalensis*, Volta lake, Ghana ($\times 1500$). c. *Sphaerospora* sp. from kidneys of *Mugil cephalus*, Kowie Lagoon, southeastern Cape, South Africa. d. Gill sphaerosporosis in farmed goldfish, Israel. e. *Henneguya* sp. from a cyst on gills of *Distichodus rostratus*, Volta lake, Ghana ($\times 1500$). f. Microsporidian infection of glomeruli in *Oreochromis aureus* kidneys, L. Kinneret, Israel. g. fibroblastic nodules containing microsporidian spores in kidneys of farmed goldfish, Israel. h-j. *Plistophora* infected swimbladder of *Haplochromis angustifrons* from L. George: histological view of infected cells of the bladder's fibrous wall (h,i) and view of the hypertrophic bladder. *Life history and biology*

All active stages of the microsporidians develop in the host cell. Two microsporidia were reported to develop within the host cell nucleus in Rodlet cells (Modin, 1981) and in haematopoietic cells (Hedrick *et al.*, 1991). The spores are the infective stage transmissible to new hosts. In the invasive stage, the uni- or binucleate sporoplasm of the spore is released through the hollowed polar filament. Development of the parasites often takes place in tissues far removed from the site of hatching, wandering macrophages and other non-differentiated mesenchymal cells probably aid their distribution or serve as hosts. Infected host cells often become grossly hypertrophic (xenoma), with concurrent enlargement of the nuclear mass (remaining single or becoming fragmented) and multiplication of nucleoli. Microsporidia are unusual in lacking mitochondria and their ribosomes are unusually large. In some microsporidia nuclei appear single ('isolated'), whereas in others nuclei are paired. Development within the xenoma proceeds through a merogonous and a sporogonous process. The sporoblasts formed from sporonts differentiate into spores (Putz and McLaughlin, 1970; Weiser, 1985; Canning & Lom, 1986).

Pathology and epizootiology: The effect of microsporidian infection on the piscine host is variable: fish seem to survive infections, in spite of the presence of

huge xenomata often pressing on and displacing important organs, while infection by some microsporidians undoubtedly has a morbid effect on the fish (Putz and McLaughlin, 1970; Morrison and Sprague, 1981). Intranuclear infection of haematopoietic cells was associated with acute anaemia (Elston *et al.*, 1987). In *Plistophora* infected *Haplochromis angustifrons* and *H. elegans*, the swimbladder walls were thick and white. Microscopic examination revealed most wall tissue to be loaded with inclusions (pansporoblasts) containing up to 48 spores. Prevalence of infection in L. George was very low (below 1%, out of 302 fish examined from both species) (Paperna, 1973). Infections by *Nosemoides tilapia* in *Tilapia zillii*, *T. guineensis* and *Sarotherodon melanotheron* were common (13–30% prevalence in Lake Nakoue and Porto Novo lagoon), with some fish demonstrating numerous xenomata on the gills (some reaching $560 \times 800 \mu\text{m}$ in size) as well as in the mesenteries, the gut wall and in the liver (up to $40\text{--}100 \mu\text{m}$ in size), but without apparent clinical effect on the fish (Sakiti and Bouix, 1987). Prevalences of infection with *Plistophora* in glass eels and elvers in Transkei rivers were 6.8–9.5% and 2.6% respectively. Microsporidian infection of kidneys in *Oreochromis* spp. are rare and do not induce any detectable pathological changes.

Control: There is no routine treatment. Fumagilin DCH used to control *Nosema* infections in bees has been tested for efficacy in treatment of microsporidian infections in fish. The drug administered in food, 0.1 g/kg food at 1.5% body weight daily ratio for four weeks, prevented mortalities and relieved *Enterocytozoon*-infected chinook salmon from clinical signs (Hedrick *et al.*, 1991). Recurrences of infection occur in treated *Plistophora* infected eels (Kano and Fukui, 1982). With elevation of doses and prolongation of treatment, toxic side-effects (haematological and stress-linked) occur (Sitja-Bobadilla and Alvares-Pelleteiro, 1992). Toltrazuril (Bayer product - 2.5% A.I.) administered by a 1h bath of 20 $\mu\text{g}/\text{ml}$ (or a 4h bath of 5 $\mu\text{g}/\text{ml}$), repeated six times at two day intervals, damaged developmental stages of the microsporidian *Glugea anomala* in sticklebacks, but did not affect spores (Schmahl and Mehlhorn, 1989).

Monogenea:

Taxonomy, description and diagnosis: Monogeneans are flatworms (Platyhelminthes), ectoparasitic and attached by special posteriorly positioned attachment organs to their host's skin or gills. Their anterior end contains apical sensory structures, a mouth with or without accessory suckers and special glands or clamps for attachment. All are hermaphrodite. The testis is single or follicular; sperm are evacuated into a specialized, often sclerotinized copulatory organ. Female organs include

ovary and follicular vitelline glands. The uterus usually contains no more than one, or only a few eggs. The South American oviparous gyrodactylids may have up to 20 intra-uterine eggs. One group, the Gyrodactylidae are viviparous; the uterus contains prenatal offspring and vitelline follicles are lacking.

Mongeneans are subdivided into several major taxa; Dactylogyroidea, Caspaloidea and Polyopisthocotylea. Most monogeneans found in inland water fish are Dactylogyroidea. Monogeneans of the latter two taxa are usually larger in size and are predominantly parasites of marine fish. Polyopisthocotylea from three genera (two families) occur in African freshwater fish.

Dactylogyroidea are 0.3–2 mm long and usually have one or two anterior-dorsal pairs of eyes and a posterior-ventral attachment organ (the opisthaptor). This disk-like organ contains centrally positioned sclerotinoid anchors, connected to support bars and marginally located hooklets. Most dactylogyroids are gill parasites, only a few are skin parasites, most notably Gyrodactylidae. A few are specialised endoparasites inhabiting the nasal cavity (*Paraquadriacanthus* - Ergens, 1988a), the stomach (*Enterogyryus* - Paperna, 1963c) and the ureter (*Acolpenteron* - Du Plessis, 1948).

Diplozoidae and the diclidophoric *Heterobothrium fluviatilis* (Euzet and Birgi, 1975) like other Polyopisthocotylea have developed secondary clamps and hooks to replace the primary dactylogyroid opisthaptor. They lack eyes and their mouth is supported by a pair of suckers. A special characteristic of Diplozoidae is the permanent attachment for copulation of pairs of mature worms (Bykhowski, 1957). Taxonomic subdivision of the Dactylogyroidea is based on structural variation in the sclerotinoid attachment organs in the opisthaptor (for the generic division) and of the sclerotinoid copulatory organ (for specific differentiation). Specific differentiation of monogeneans other than Dactylogyridae requires consideration of a wider range of morphological and anatomical characters (Bykhowski, 1957; Paperna, 1979). Lower taxa of Dactylogyroidea can be differentiated as follows:

Gyrodactylidae: Viviparous, eyes absent, parent worm contains a distinct well differentiated embryo. Vitellaria not distinct, one pair of anchors, firmly attached by two bars. *Gyrodactylus* is the type genus. Species from the other genus, *Macroglyrodactylus*, are larger and carry additional sclerites in the anchor-bar complex. All remaining Dactylogyroidea are oviparous with prominent vitelline follicles, usually with one to two pairs of pigmented eyes, the anchor only loosely connected (through ligaments) with the bars.

Diplectanidae: Anchors, two pairs, associated with three bars and ventral and dorsal concentric platelets (the

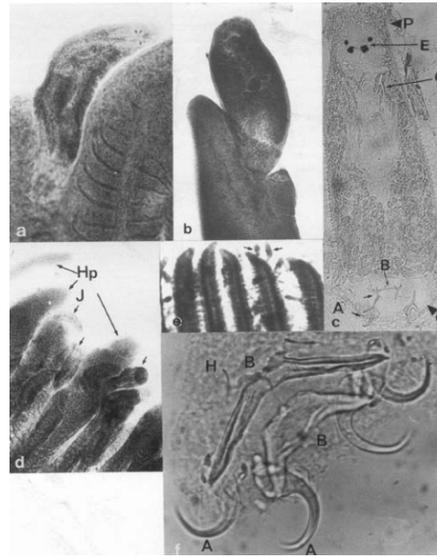


Plate 3: Dactylogyrid monogenea

squamodiscs). *Diplectanum lacustris* in gills of *Lates* spp. (Thurston & Paperna, 1969). The parasite population was comprised of slender (0.6–1.0 × 0.15–0.25 mm) and gravid (1.0–2.0 × 0.3–0.5 mm) worms (Paperna, 1979). Slender and gravid forms of *Diplectanum* in *Dicentrarchus punctatus* were separated into two distinct species (Lambert and Maillard, 1974).

Dactylogyridae: Squamodiscs absent. *Pseudoacolpenteron* and *Acolpenteron* have only marginal hooklets, the first is a gill ectoparasite of carp and has eyes. The second is an endoparasite of the urinary system. The genera *Dactylogyryus* and *Dogielus*, parasitic in cyprinids, have one pair of anchors. Members of genera characterised by two pairs of anchors (similar or dissimilar in size) and a variable number of bars (Ancyrocephalinae) occur in a variety of African fish families (Paperna, 1979; Ergens, 1981, 1988a, 1988b; Kritsky *et al.*, 1987; Kritsky and Kulo, 1988, 1992; Douellou, 1993).

Plate 3 shows Dactylogyrid Monogenea: a. *Dactylogyryus vastator* carp fry from a pond, Israel (0.9 mm long). b. *Diplectanum lacustris* ‘gravid’ form (1.5 mm long) on gill filament tip of *Lates niloticus*, northern L. Victoria. c. *Enterogyryus cichlidarum* from stomach of *Tilapia zillii*, Israel (280 mm long); A. Anchors, B. Bars, C. Copulatory organ. E. Eyes, O. Opisthaptor, P. Prohaptor. d. Pre-mature (transparent, J) and mature (filled with granular vitellaria) *D. vastator* inducing epithelial proliferation (Hp) in gills of carp fry. e. *Dactylogyryus anchoratus* infesting gills of young carp. f. Anchors (A), Bars (B) and hooklets (H) in the opisthaptor

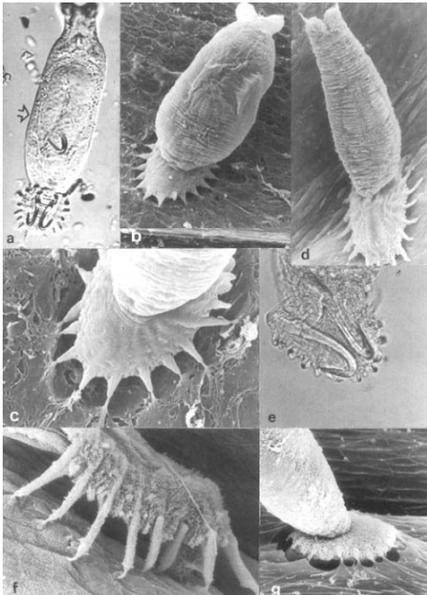


Plate 4: Dactylogyrid monogenea

of *Quadriacanthus clariadis*, from *Clarias gariepinus*, L. Victoria.

Plate 4. shows Gyrodactylid Monogenea: a. *G. mugili* from *Mugil saliens* skin from an Israeli Mediterranean estuarine habitat, life (arrow intrauterine offspring). b.

Scanning electron micrographs (SEM) of *G. cf. medius* from farmed goldfish, Israel. c. Details of opisthaptor attachment of b. d. SEM of *G. cichlidarum* from skin of Israeli farmed tilapia hybrids. e. Opisthaptor of *G. cichlidarum* from *Oreochromis* sp. from Uganda, life. f. SEM details of opisthaptor of d. SEM details of opisthaptor of *G. cichlidarum* from *O. leucostictus*, Lake Naivasha, Kenya.

Fig. 1a. Monogenea: A. General view of *Cichlidogyrus arthracanthus* (400 µm long) from *Tilapia zillii*. B–W. Opisthaptor armature of species representing major genera of African Dactylogyroidea: B. *Cichlidogyrus halli*, hosts: *Oreochromis* and *Sarotherodon* spp. C. *Onchobdella voltensis*, hosts: *Hemichromis* spp. D. *Diplectanum lacustris*, hosts: *Lates* spp. E. *Dogielus dublicornis*, host: *Labeo cylindricus*. F. *Dactylogyrus afrofluviatilis*, hosts: *Barbus* spp. G. *Acolpenteron pavlovskii*, host: *Cyprinus carpio*. H. *Heterotesia voltae*, Host: *Heterotis niloticus*. I. *Jainus* (= *Characidotrema*) *longipenis*, host: *Alestes leuciscus*. J. *Ancyrocephalus* s.l. *synodontis*, hosts: *Synodontis* spp. K. *Quadriacanthus clariadis*, hosts: *Clarias*, *Heterobranchus* and *Bagrus* spp. L. *Bagrobdella auchenoglanii*, host: *Auchenoglanis occidentalis*. M. *Protoancylo-discoides chrysiichthes*, host: *Chrysiichthys nigrodigitatus*. N. *Schilbetrema acornis*, host: *Schilbe mystus*. O. *Schilbetrema bicornis*, host: *Physalia pellucida*. P. *Eutrianchoratus magnum*, host: *Ophiocephalus obscurus*.

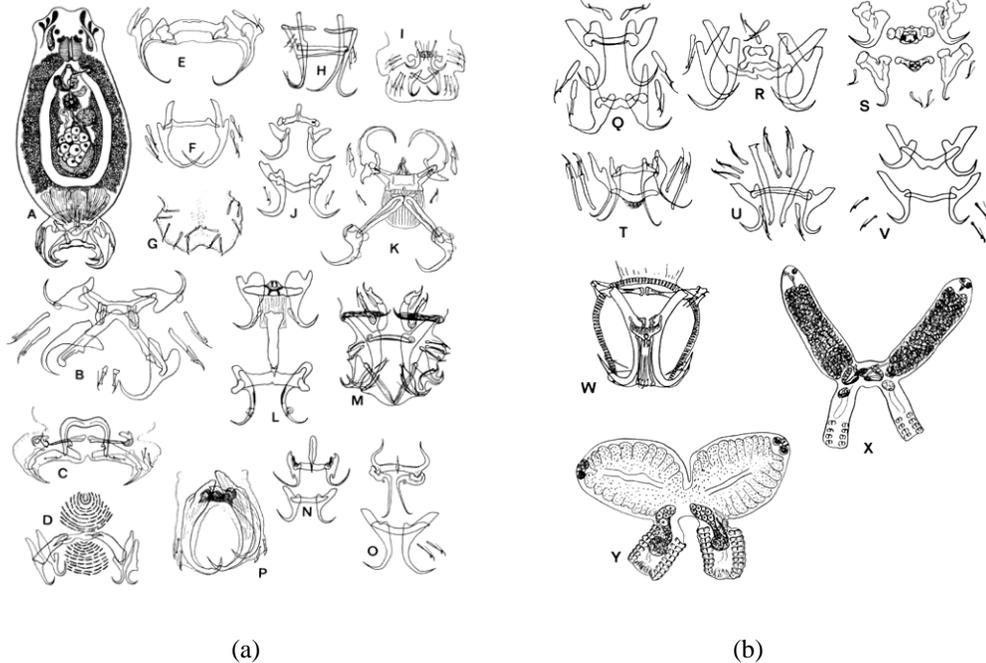


Fig. 1: Monogenea Source: docrep_redirector_head_cache_data

Fig. 1b. Monogenea continued: Q. *Ancyrocephalus* s.l. *barilii*, hosts: *Barilius* spp. R. *Afrocleidodiscus paracleidodiscus*, host: *Distichodus niloticus* (another species on *Hydrocynus* spp.). T. *Annulotrema gravis*, hosts: *Alestes* spp. U. *Nanotrema citharini*, host: *Citharinus citharus*. V. *Ancyrocephalus* s.l. *pellonulae*, host: *Pellonula afzeliusi*. W. *Macrogyrodactylus ctenopomae*, host: *Ctenopoma muriei*. X. *Diplozoon aegyptiensis* general view ($\times 20$). Y. *Neodiplozoon polycotyleus*, general view ($\times 60$).

A variety of species found in hosts of diverse fish families have been assigned to *Ancyrocephalus*, but in fact are representatives of diverse (still undefined) generic entities. *Cichlidogyrus*, *Onchobdella* (with one species adapted to infect the skin - Paperna, 1968a, b) and *Enterogyrus* (endoparasitic in the stomach) are host specific to diverse cichlid fish species. The genera *Annulotrema* and *Characidotrema* are host specific to characid fish. *Afrocleidodiscus* occurs in both Characidae and Citharinidae and fish of the latter family are also hosts for *Nanotrema*. Several genera occur in siluriforms, some are congeneric (*Quadriacanthus*) and others have a definite affiliation to dactylogyroids infecting Southeast Asian silurids (Ha, 1968; Paperna, 1979). Dactylogyridae which have partly or completely lost one of their four anchors (Heterochocleidinae) parasitise gills of *Ophiocephalus* (*Eutrianchoratus*) and *Ctenopoma* (*Heteronchocleidus*) (Paperna, 1969; Euzet and Dossou, 1975), and are affiliated to dactylogyrids infecting fish of the same families (Ophiocephalidae and Anabantidae) in Southeast Asia (Lim, 1986, 1989).

Diplozoidae of two genera occur in African fish; *Diplozoon* (*D. ghanense* in *Alestes* spp. and *D. aegyptiensis* in various cyprinids) and *Neodiplozoon* (two spp. in *Barbus* spp.) these being differentiated by the number and arrangement of the clamps (Paperna, 1979). The other polyopisthocotylid, *Heterobothrium fluviatilis* occurs on *Tetraodon fahaka* (Euzet & Birgi, 1975).

For differential diagnosis, worms should be removed from the gills or the skin. This must be performed on freshly killed fish. Gills should be removed without excessive haemorrhaging and before becoming covered by copious mucus. Mucus production is prevented and worms are readily collected from gills after a few hours immersion in 1–2% formalin. For microscopic study of the sclerotinoid organs, required for differential diagnosis of Dactylogyroidea, worms are either embedded after fixation in 4% formalin, under pressure in glycerin jelly, or fixed and embedded in ammonium-picrate-glycerin. Both preparations are suitable only for temporary storage (6 months–1 year). For the larger non-dactylogyroid monogeneans (for example *Diplozoon*), fixation and staining methodology for tapeworms and trematodes should be applied.

Life history and biology: All monogeneans except gyroactylids are oviparous. The uterus contains only very few eggs, often only one, but overall daily production may range from 5 up to 60. Egg production varies with age of the worm. Adverse living conditions (due to water quality or host responses) often accelerate oviposition (Izumova, 1956) and eggs are deposited undeveloped. All eggs except those of dactylogyroids have a long filament which helps the egg to remain tied to the gill basket or to a substrate in the water. The filament in the dactylogyrid egg is rudimentary and development of the egg to hatching takes place on the bottom of the aquatic habitat (Bykhovskii, 1957; Paperna, 1963a; Imada and Muroga, 1978).

Incubation time is temperature dependent. Eggs of *Dactylogyrus* species from carp hatch within two to six days at temperatures of 20–28°C. Embryonic development is enhanced and hatching is stimulated in the presence of fish mucus (Shaharom-Harrison, 1986). Emerging larvae (onchomiracidia) are free swimming, covered by tufts of cilia, bear two pairs of large pigmented eyes and already have a distinct opisthaptor with developed marginal hooks (hooklets) and primordia of anchors. The life span of the free swimming larvae at 20–28°C is 12–48h, but after 4–6 hours larvae apparently lose their ability to reach their hosts (Izumova, 1956; Bauer, 1959; Paperna, 1963a; Prost, 1963). Larvae are either actively attached to the skin of the host fish and then migrate to the gills or become attached when washed with swallowed water through the gills (Paperna, 1963a, b).

In dactylogyroids, development to maturity is usually fast (4–5 days) and life span is short, 5–40 days (Paperna, 1963a, 1963b; Shaharom-Harrison, 1986). Development of Diplozoidae to maturity and to the formation of copulating couples is slower, while the life-span of the adult worm is extended from several months to two years. *Diplozoon paradoxum* infecting European fish reach maturity only after 4 months, the life-span extending to two years and with reproductive activity restricted to the warmer part of the year (Bovet, 1967). Prolonged life span (over a year) with reproduction limited to the warmer part of the year (although intrauterine eggs were seen also in winter) has been observed in *D. minutus* infecting small cyprinids of the genera *Tylognatus* and *Phoxinellus* in Lake Kinneret, Israel (Paperna, 1963d, 1964a,b).

Species found on tropical fish may have a considerably shorter development, of one to a few weeks and a life span of less than a year. In Diplozoids (of the genera *Diplozoon* as well as *Neodiplozoon*), pairs of clamps appear gradually as the larvae differentiate, development is asymmetric and developing worms may show unpaired numbers of clamps (Paperna, 1963d, 1979). *D. minutus* juveniles join into couples before they

reach maturity, at stages ranging from one pair to several pairs (or unpaired) clamps. Couples may be comprised of worms at different stages of differentiation as evident from a disparity in the number of clamps between the coupling worms. Larval stages were found to be less fastidious in their choice of host and natural as well as experimental hosts include other genera of cyprinids, juvenile carp and *Oreochromis* spp., but formed couples only on their specific hosts (Paperna, 1963d).

The Gyrodactylidae are viviparous. Worms give birth to fully developed adults. Intra-uterine embryos already contain second and often third generation embryos, recognised by their developing marginal hooklets and anchors. The life cycle of *Gyrodactylus bullatardis* on *Lebistes reticulatus*, from egg to egg at an ambient temperature of 25–27°C, is completed within 54–60 hours; new specimens first give birth, followed by each subsequent birth, after 18 hours. Eggs develop into embryos ready to be born within 36 to 42 hours (Thurnbull, 1956; Bykhowskii, 1957). The succession of embryos is formed through a process of polyembryony. The new born worm gives birth at least twice before it is inseminated and its own egg becomes fertilised. One of the blastomeres formed in the very early cleavages, separates and later becomes the origin of the following generations. Each fertilized egg gives rise to two subsequent series of embryo successions. In the new born worm male genitalia are still rudimentary, and become functional in older specimens when female reproduction ceases. Passage from host to host requires a direct physical contact between the fish (Thurnbull, 1956; Hoffman and Putz, 1964; for detailed description of the reproductive development of *Macrogyrodactylus polypteri* see Khalil, 1970).

Pathology: Fish appear to co-exist with their specific monogeneans, in natural habitats as well as in culture conditions, even when infestations are intense. A few monogeneans, notoriously gyrodactylids, are, however, pathogenic to their host fish, usually to younger fish and in intensive culture conditions. Histopathological changes in the gills, are hardly detectable in most instances even in relatively intense infections. In *Lates albertianus*, intense hyperplasia developed around *Diplectanus lacustris* attached to gills; diplectanid infections are nonetheless pathogenic to cultured marine fishes (Oliver, 1977; Paperna, 1991).

D. vastator infection, in the gills of carp fry, induces severe hyperplasia of the gill filament epithelium. Extreme proliferation of the respiratory epithelium of the gills interferes with respiratory function and seems to be the cause of death (Paperna, 1963b, 1964c). *D. lamellatus*, in grass carp, induces epithelial proliferation, but also wounds the gill filaments where it is attached (Molnar,

1972). The largest among carp dactylogyrids, *D. extensus*, causes only focal cellular damage at its attachment site at the filament base. However, infections by this parasite were nonetheless, at times, fatal to both young and fully grown fish (Bauer, 1959; Prost, 1963; Sarig, 1971). In carp fry, *D. vastator* loses its attachment once the entire gill filament is taken by hyperplasia. Worm populations decline from 50–130 to 0–25 per fish at the height of the proliferation process. Recovery of the gill integument in surviving fish results in reinfection and consequently renewal of the proliferation process. *D. vastator* preferentially settles at the extremities of the gill filament. With the elongation of the gill filaments in growing fingerlings, the parasites and the induced hyperplasia remain restricted to the tips, leaving the remaining filament functional. Mortality never occurred in fish longer than 32–35 mm, which survived heavy infections as high as 300 parasites per fish (Paperna, 1963b).

Acolpenteron ureteroecetes infecting the ureter of *Micropterus salmoides* causes inflammatory changes. Acute conditions were accompanied by dropsy and chronic infection of the ureter leads to blockage swelling and deposition of a crystalline precipitate. Degenerative and necrotic changes also extend to the posterior end of the kidney (Du Plessis, 1948). There are no records of ill effects due to dactylogyrid infections in cichlids in Africa or Israel, even when infections are high. However, of the five monogeneans introduced with *Oreochromis* spp. to Southeast Asia, one of these, *Cichlidogyrus sclerosus*, has been reported to harm cultured fish (Kabata, 1985).

Some of the species of *Quadriacanthus* infecting clariid catfish are apparently also potentially pathogenic and morbid infections with unidentified species were reported from farmed catfish (*Clarias batrachus*) in Southeast Asia (Kabata, 1985).

In eels (*Anguilla* spp.), reared in warm water farming systems and infected with *Pseudodactylogyrus anguillae* and *P. bini*, the mouth and branchial zone, as well as the gills become hyperemic, there is increased mucus secretion, and erosion of the lamellar texture or, in other cases, extensive hyperplasia of the gill epithelium (Chan and Wu, 1984; Buchmann *et al.*, 1987). Fish heavily infected with *Gyrodactylus* appear pale, due to excessive mucus secretion and epithelial proliferation. In the more heavily infected skin zones, there is skin erosion; desquamation of the skin epithelium, focal haemorrhagic lesions and loss of scales (Tripathi, 1957; Gopalakrishnan, 1963; Kabata, 1985). Obiekezie and Taege (1991) reported severe mortalities (up to 90%) of *Clarias gariepinus* fry (two weeks old) in a hatchery in Nigeria, due to a severe infestation by *Gyrodactylus groschaffi*. Khalil (1964) reported fatal hyperinfections (690–7340 worms per fish) by *Macrogyrodactylus polypteri* of aquarium held *Polypterus senegalus*. Species of

Macrogyrodactylus occur in fish with potential for aquaculture in Africa, *Clarias* spp., *Lates niloticus* and Anabantidae (Paperna, 1979).

Immunity: Spontaneous decline of infection has been reported in both dactylogyrid and gyrodactylid infections. Surviving Carp fingerlings (31–61 mm long) spontaneously recovering from *D. vastator* infection in ponds, resisted reinfection for about 40 days after its onset. Fish, reared free of infection to the size of 65–80 mm became readily infected when exposed, but infection in such fish never lasted more than 12 days (Paperna, 1964c). Spontaneous recovery of *P. senegalus* from *Macrogyrodactylus polypteri* infection occurred after two weeks (Khalil, 1964).

Injections of hydrocortisone caused elevation of infection levels in *Oreochromis* spp. with both *Cichlidogyrus sclerosus* and *Gyrodactylus* sp. (Shaharom-Harrison, 1986).

Epizootiology: Monogeneans, Dactylogyridae in particular, are highly host specific, and seem to have co-evolved with their hosts. The same parasite species, however, often infects several fish species of the same genus or species group, and parasites occurring on the host of the same fish family are taxonomically related, usually at the generic level (example: *Cichlidogyrus* and Cichlidae). Such co-evolutionary relationships are less evident in Gyrodactylidae in which species of the same genera (e.g. *Gyrodactylus*, *Macro-gyrodactylus*) occur in representatives of diverse fish families, although individual species, if correctly determined, seem to be narrowly host specific (Malmberg, 1970); this also applies to species infecting African fish (Paperna, 1979). Among species of *Polypterus*, only *P. senegalus* succumbed to massive infestation of *Macrogyrodactylus polypteri*; all others exposed under similar conditions became only lightly infected (Khalil, 1964).

In most fish species associated with monogeneans, incidence is high (approaching 100%) and intensities of 20–100 or more worms per fish are common (Paperna, 1964a, 1979; Batra, 1984). Crowding fish into culture systems or aquaria often promotes infestation. Introduction of *Polypterus senegalus* into aquaria caused an exponential increase in infestations with *Macrogyrodactylus polypteri*, resulting in a worm burden of 690–7340 per fish within 20–25 days. Natural infections of the same fish species and parasites in the Nile did not exceed 6 worms per single fish (Khalil, 1964). In small habitats and culture systems, the predicted increase in infestation is, however, not always fulfilled, due to the inhibitive quality of physical (depth, currents, temperatures) and chemical (oxygen, salinities) factors of the environment.

In such habitats, decline has also been observed in the diversity of the monogenean species, for example, cichlids usually infected with a variety of species, becoming infected by a single species only (*C. arthracanthus* in *T. zillii* and either *C. tilapiae* or *C. sclerosus* in *Oreochromis* spp.) (Paperna, 1963d, 1979). Species of dactylogyrids as well as gyrodactylids demonstrate different tolerances to water salinity. Particularly tolerant to euryhaline waters are *D. extensus* (infecting carp) (Paperna, 1964a) and *G. cichlidarum* (infecting cichlids) which are tolerant to water of 1 ppt salinity. Heavy infections of *Diplectanus lacustris* occur in introduced Nile perch in Lake Kyoga and the Victoria Nile, while being low in Nile perch in their native Lake Albert.

Massive mortalities due to heavy urethral infection by *Acolpenteron ureteroecetes* in hatchery reared, introduced *Micropterus salmoides* were reported in South Africa (Du Plessis, 1948).

Species of *Dactylogyrus* are often introduced with carp. European populations of *D. anchoratus*, *D. minutus* and *D. vastator* infecting carp are thermophilic, with optimal reproduction at ambient water temperatures of 28–29°C, while the high oxygen demand of the developing eggs of *D. extensus* causes a decline in hatching rate at elevated ambient temperatures (from 75% at 14°C to 9% at 20°C) and results in an optimal rate of reproduction at 17°C ambient water temperature (Izumova, 1956; Bauer, 1959). *D. extensus*, as well as all other introduced *Dactylogyrus* spp., however, become well adapted and thrive in the eutrophic warm water conditions of Israeli fish ponds (28–30°C, and dissolved oxygen at times declining to 0.4 mg/l) (Paperna, 1964a). Heavy infestations by *D. vastator* caused mass mortality of carp fry (<35 mm in length) during the spawning season (spring to early summer) in breeding and nursery ponds in Israel. Epizootiological investigation of the circumstances under which these mortalities occurred revealed the following (Paperna, 1963a):

Mortalities only occurred in ponds which were used every year to rear fry, and most often in ponds where mortalities had been recorded in preceding years. The fish population density of affected ponds was always above 5 million fry per hectare (about 0.25 kg biomass per 1m³). Daily growth increments of fry in such ponds were less than 1 mm (sometimes only 0.5 mm), compared with a daily growth increment of 1.3–1.6 mm in low density (<500,000 fry/hectare) ponds. Parasites appeared simultaneously by mid-April in fry-stocked ponds of different regions and farms. Mortalities usually occurred 25–35 days after spawning, in 18–26 mm fish. Survivors of the mortalities in the ponds gradually lose the infection. Mortalities never occurred, irrespective of stocking density, in ponds where infection had not been established

soon after spawning. Delay in establishment of infection (10–44 days post-spawn) occurred in ponds spawned prior to April (where a warm [20–24°C] ground water supply is available) or in ponds not used for fry production in previous years.

Circumstantial evidence suggests that infection originated annually from “resting” eggs remaining in the ponds from the previous year's growing season. Parasites were never found on fish other than fry and fingerlings or outside the breeding season (August–April) (Paperna, 1963a, b). Growth conditions in the ponds - water quality and stocking densities are the predisposing factors to infections and losses of carp due to *D. extensus* (Bauer, 1959; Sarig, 1971), grass carp due to *D. lamellatus* and bighead carp (*Aristichthys nobilis* due to *D. nobilis* (Molnar, 1971; Bauer *et al.*, 1969; Shaharom-Harrison, 1986). The same applies to infections by *Pseudodactylogyrus* spp. of eels farmed in warm water systems (Chan & Wu, 1984; Buchmann *et al.*, 1987).

Epizootic gill infections by *D. baueri* and *D. formosus* and skin and gill infections with *Gyrodactylus medius* occur in commercially reared goldfish during overcrowding in tanks before marketing. In Israel, heavy infections of hatchery hybrid ‘tilapia’ fry by *Cichlidogyrus* spp. combined with epizootic infestations of trichodines and *Tripartiella cichlidarum* were suggested to be pathogenic (Landsberg, 1989). Overwintering tilapia in ponds are concurrently infected by *Gyrodactylus cichlidarum* and *Chilodonella* spp. In carp, heavy gyrodactylosis was seen in fish with skin papilloma. Clinical *Gyrodactylus* infections have been reported also to trouble intensively farmed ‘tilapia’ in Kenya. Mortalities associated with epizooties were reported to occur two weeks after handling and transfers (Roberts and Sommerville, 1982).

Control: Infections of *Dactylogyrus* spp. in carp fry and fingerlings in earth ponds are controlled through application of 0.12 ppm (A.I.) Bromex (Dibrom, Naled). Repetition of treatment within a week is recommended. The safety index for carp fry is 32 (Sarig, 1971). Elsewhere another organophosphate -- Masoten (Dipterex, Neguvon, Dylox) is used at a dose of 0.25–0.50 ppm (A.I.). The safety index for carp fry is 12 (Sarig *et al.*, 1965; Schmahl, 1991). Quick treatment with a mixture of 2 ppm of 50% DDVP (DP, dichlorovos, Vapona), 0.2 ppm Bromex and 25 ppm Formalin (36% Formaldehyde) for 4–6 hours has been recommended to clear ‘tilapia’ fry in hatchery tanks infested with both *Cichlidogyrus* and trichodines (Landsberg, 1989). The same treatment has been applied to *Gyrodactylus* infections.

Some populations of *Gyrodactylus elegans* in goldfish, however, demonstrated an apparent resistance to a dosage as high as 12.5 ppm and in some instances also 25 ppm (Goven *et al.*, 1980). A resistance to bromex seems to be also developing among *Gyrodactylus medius*

infesting commercially farmed goldfish in Israel. Recently the use of Praziquantel has been advocated (a 3 hour bath in 10 mg/l solution at 22°C - Schmahl and Mehlhorn, 1985) and data were provided on the efficacy of other anthelmintic drugs such as Levamisol (2h bath in 50 ml/l), Niclosamide (2 h bath in 0.075–0.1 ml) and Mebendazole (24h bath of 1 mg/l) (Schmahl, 1991). Praziquantel is at present too expensive for commercial use, the other drugs need more extensive testing before being considered for routine use.

CONCLUSION

Adequate knowledge on the description, taxonomy and diagnosis, Pathology, Life cycle and biology, Epizootiology and Control of Myxosporea, Microspora and Monogenea in African fish is important in educating fish culturist on more challenges faced in culture fisheries.

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To God be the Glory.

REFERENCES

- Abolarin, M.O., 1974. *Myxobolus tilapiae* sp. nov. (Protozoa: Myxosporidia) from three species of freshwater tilapia in Nigeria. J. West Afr. Sci. Ass., 19: 109-114.
- Baker, J.R., 1963. Three new species of *Myxosoma* (Protozoa: Myxosporidia) from East African freshwater fish. Parasitol., 53: 285-292.
- Bassey, S.E., 2011. A Concise Dictionary of Parasitology. 1st Edn., Zetus Concepts, Port Harcourt, pp: 115, ISBN: 978-2954-40-3.
- Batra, V., 1984. Prevalence of helminth parasites in three species of cichlids from man-made lake in Zambia. Zool. J. Linn. Soc., 82: 319-333.
- Bauer, O.N., 1959. The ecology of fresh water fish. Inves. Gosud. Nauch-Issled. Inst. Ozer. Rech. Ryb. Khoz., 49: 5-206 (In Russian, English transl. Israel Prog. Sci. Trans. Cat. No. 622, 1962, 3-215).
- Bauer, O.N., V.A. Musselius and A.Y. Strelkov, 1969. Diseases of Pond Fishes. Publisher “Kolos” Moskva. In English: Israel Program for Scientific Translations, Jerusalem, 1973.
- Bauer, O.N., V.N. Voronin and O.N. Yunchis, 1991. Infection of the heart in carp caused by *Myxobolus dogieli* (Myxosporidia, Myxobolidae). Angew. Parasitol., 32: 42-44.
- Bondad-Reantaso, M.G. and J.R. Arthur, 1990. The Parasites of Nile Tilapia (*Oreochromis niloticus* (L.)) in the Philippines, Including an Analysis of Changes in the Parasite Fauna of cultured Tilapia from fry to marketable size. In: Hirano, R. and I. Hanyu, (Eds.), The Asian Fisheries Forum, Asian Fisheries Society, Manila, Philippines, pp: 729-734.

- Bovet, J., 1967. Contribution a la morphologie et la biologie de *Diplozoon paradoxum* V. Nordmann, 1832. Bull. Soc. Neuchatel. Sci. Nat., 90: 63-159.
- Buchmann, K., Mellergaard, S. & Koie, M., 1987. *Pseudodactylogyru*s infections in eels: a review. Dis. Aquat. Org., 3: 51-57.
- Canning, E. and J. Lom, 1986. The microsporidia of vertebrates. Academic Press.
- Chan, B. and B. Wu, 1984. Studies on the pathogenicity, biology and treatment of *Pseudodactylogyru*s for the eels in fish farms. Act. Zool. Sinica, 30: 173-180.
- Csaba, G., E. Kovac-Geyer, L. Bekesi, M. Bucsek and K. Molnar, 1984. Studies into the possible aetiology of swimbladder inflammation in carp fry. J. Fish Dis., 7: 39-56.
- Current, W.L. and J. Janovy, 1976. Ultrastructure of interlamellar *Henneguya exilis* in the channel catfish. J. Parasitol., 62: 975-981.
- Diamant, A., 1992. A new pathogenic histozoic *Myxidium* (Myxosporea) in cultured gilt-head sea bream *Sparus aurata* L. Bull. Eur. Ass. Fish Pathol., 12: 64-66.
- Douellou, L., 1993. Monogeneans of the genus *Cichlidogyru*s Paperna, 1960 (Dactylogyridae: Ancyrocephalinae) from cichlid fishes of Lake Kariba (Zimbabwe) with description of five new species. Syst. Parasitol., 25: 159-186.
- Du Plessis, S.S., 1948. A gyrodactylid parasite from the ureters of large mouth bass at the Jonkershoek inland fish hatchery, South Africa. Trans. Am. Fish. Soc., 75: 105-109.
- Dykova, I and J. Lom., 1982. *Sphaerospora renicola* n. sp., a myxosporean from carp kidney, and its pathogenicity. Z. Parasitenk., 68: 259-268.
- Dykova, I., J. Lom and M. Cirkovic, 1986. Brain myxoboliasis of common carp (*Cyprinus carpio*) due to *Myxobolus encephalicus*. Bull. Eur. Ass. Fish Pathol. 6: 10-12.
- Dykova, I and J. Lom., 1992. *Sphaerospora renicola* n. sp., a myxosporean from carp kidney, and its pathogenicity. Z. Parasitenk., 68: 259-268.
- El Matbuli, M. and R.W. Hoffmann, 1989. Experimental transmission of two *Myxobolus* spp. developing bisporogony via tubificid worms. Parasitol. Res., 75: 461-464.
- El Matbouli, M and R.W. Hoffmann., 1991. Prevention of experimentally induced whirling disease in rainbow trout *Oncorhynchus mykiss* by fumagillin. Dis. Aquat. Org., 10: 109-113.
- Elston, R.A., M.L. Kent and L.H. Harrel, 1987. An intranuclear microsporidium associated with acute anaemia in the chinook salmon. J. Protozool., 34: 247-277.
- Ergens, R., 1981. Nine species of the genus *Cichlidogyru*s Paperna, 1960 (Monogenea: Ancyrocephalinae) from Egyptian fishes. Folia Parasitol., 28: 205-214.
- Ergens, R., 1988a. Four species of the genus *Annulotrema* Paperna & Thurston, 1969 (Monogenea: Ancyrocephalinae) from Egyptian freshwater fish. Folia Parasitol., 35: 209-215.
- Ergens, R., 1988b. *Paraquadriacanthus nasalis* gen. et sp. n. (Monogenea: Ancyrocephalidae) from *Clarias lazera* Cuvier et Valenciennes. Folia Parasitol., 35: 189-191.
- Euzet, L. and E. Birgi, 1975. *Heterobothrium fluviatilis* n. sp. (Monogenea, Dicliphoridae) parasite branchial due *Tetraodon fahaka* Bennet, 1834 (Teleostei) au Tchad. Bull. Soc. Zool. Fr., 100: 411-420.
- Euzet, L. and C. Dossou, 1975. Parasites des poissons d'eau douce du Dahomey. 1. Espèces nouvelles du genre *Heteronchocleidus* (Monogenea), parasites d'Anabantidae. Bull. Mus. Natl. Hist. Nat. (Série Ser.) Zool., 282: 23-34.
- Fahmy, M.A.M., A.M. Mandour and M.K. El Naffar, 1975. A survey of myxosporidia of freshwater (fish) collected from the river Nile at Assiut province. J. Egypt. Soc. Parasitol., 4(5): 93-102.
- Fryer, G., 1961. Observation on the biology of the cichlid fish *Tilapia variabilis* Boulenger in the northern waters of Lake Victoria (East Africa). Rev. Zool. Bot. Afr., 64: 1-33.
- Gopalakrishnan, V., 1963. Diseases and parasites of fishes in warm water ponds in Asia and the far East. FAO Fish Rep., 44(5): 319-343.
- Goven, B.A., J.P. Gilbert and J.B. Gratchek, 1980. Apparent drug resistance to the organophosphate dimethyl (2,2,2 - trichloro-1-hydroxyethyl) phosphonate by monogenetic trematodes. J. Wild. Dis., 16: 343-346.
- Gussev, A.V., 1976. Freshwater Indian Monogenoidea, principals of systematics, analysis of the world fauna and their evolution. Indian J. Helm., 25(26): 1-241.
- Ha, K., 1968. New species of Monogenea from freshwater fish of North Viet Nam. Parasitologia, 2: 247-301.
- Hedrick, R.P., J.M. Groff, P. Foley and T. McDowell, 1988. Oral administration of fumagillin DCH protects chinook salmon *Onchorhynchus tshawytscha* from experimentally-induced proliferative kidney disease. Dis. Aquat. Org., 4: 165-168.
- Hedrick, R.P., J.M. Groff and D.V. Baxa., 1991. Experimental infection with *Enterocytozoon salmonis* Chiltonczyk, Cox, Hedrick (Microsporea): An intranuclear microsporidium from chinook salmon *Onchorhynchus tshawytscha*. Dis. Aquat. Org., 10: 103-108.
- Hoffman G.L. & Putz, R.E., 1964. Studies on *Gyrodactylus macrochiri* n. sp. (Trematoda: Monogenea) from *Lepomis macrochirus*. Proc. Helm. Soc. Wash., 31: 76-82.

- Imada, R and K. Muroga., 1978. *Pseudodactylogyrus microrchis* (Monogenea) on the gills of cultured eels-II. Oviposition, hatching and development on the host. Bull. Jap. Soc. Scient. Fish., 44: 571-576.
- Izumova, N.A., 1956. Materials on the biology of *Dactylogyrus vastator* Nybelin. Parasitologicheskii Sbornik Zool. Instituta, Akad. Nauk SSSR, 16: 229-244 (in Russian, English summary).
- Izumova, A.N., 1958. Oxygen regime of a basin as one of the factors influencing the biology of *Dactylogyrus solidus* and *Dactylogyrus vastator*. Parasitologicheskii Sbornik Zool. Instituta Akad. Nauk SSSR, 18: 295-303 (in Russian, English summary).
- Jackson, P.B.N., 1978. Health and disease in intensive aquaculture. J. S.A. Vet. Ass., 49: 57-59.
- Kabata, Z., 1985. Parasites and Diseases of Fish Cultured in the Tropics. Taylor & Francis, London & Philadelphia.
- Kalavati, C. and C.C. Narasimhamurti, 1985. Histopathological changes in the gills of *Channa punctatus* BL. infected with *Henneguya waltirensis*. Arch. Protistenk., 129: 199-202.
- Kano, T. and H. Fukui, 1982. Studies on *Pleistophora* infection in eel, *Anguilla japonica*-I. Experimental induction of microsporidiosis and fumagilin efficacy. Fish Pathol., 16: 193-200.
- Kent, M.Land R.P. Hedrick., 1985. PKX, the causative agent of proliferative kidney disease (PKD) in pacific salmonid fishes and its affinity with the Myxozoa. J. Protozool., 32: 254-260.
- Khalil, L., 1964. On the biology of *Macrogyrodactylus polypteri* Malmberg, 1956, a monogenetic trematode on *Polypterus senegalus* in the Sudan. J. Helminth., 38: 219-222.
- Khalil, L.F., 1970. Further studies on *Macrogyrodactylus polypteri*, a monogenean on the African Freshwater Fish *Polypterus senegalus*. J. Helminth., 44: 329-348.
- Khalil, L.F., 1971. Checklist of the Helminth Parasites of African Freshwater Fishes. Tech. Comm. 42, Comm. Inst. Helm., C.A.B. England, pp: 80.
- Korting, W., 1982. Protozoan parasites associated with swimbladder inflammation (SBI) in young carp. Bull. Eur. Ass. Fish Pathol., 2: 25-28.
- Kovac-Geyer, E. and K. Molnar, 1983. Studies on the biology and pathology of the common carp parasite *Myxobolus basilamellaris* Lom & Molnar, 1983 (Myxozoa: Myxosporea) Acta Vet. Hungar., 31: 91-102.
- Kritsky, D.C. and S.D. Kulo, 1988. The African species of *Quadriacanthus* with proposal of *Quadriacanthoides* gen. n. (Monogenea: Dactylogyridae). Proc. Helm. Soc. Wash., 55: 175-187.
- Kritsky, D.C., S.D. Kulo and W.A. Boeger, 1987. Resurrection of *Characidotrema* Paperna & Thurston, 1968 (Monogenea: Dactylogyridae) with description of two new species from Togo, Africa. Proc. Helm. Soc. Wash., 54: 175-184.
- Kritsky, D.C. and S.D. Kulo., 1992. A revision of *Schilbetrema* (Monogenoidea: Dactylogyridae) with description of four new species from African Schilbeidae (Siluriformes). Trans. Am. Mic. Soc., 111: 278-301.
- Lambert, A. and C. Maillard, 1974. Parasitisme branchial simultane par deux especes de *Diplectanum* Diesing 1858 (Monogenea, Monopisthocotylea) chez *Dicentrarchus labrax* (L. 1758) Teleosteen. Comp. Rend. Acad. Sci. Paris, 279(Ser. D): 1345-1347.
- Landsberg, J.H., 1985. Myxosporean infections in cultured tilapia in Israel. J. Protozool., 32: 194-201.
- Landsberg, J.H., 1986. Myxosporean parasites of the catfish, *Clarias lazera* (Valenciennes). Syst. Parasitol., 9: 73-81.
- Landsberg, J.H., 1989. Parasites and Associated Diseases of Fish in Warm Water Culture with Special Emphasis on Intensification. In: Shilo, M. and S. Sarig, (Ed.) Fish Culture in Warm Water Systems: Problems and Trends. CRC Press Inc., Boca Raton, Flo, pp: 195-252.
- Lim, L. H. S., 1986. New species of *Trianchoratus* Price et Berry, 1966 (Ancyrocephalidae) from Malayan anabantoid fishes. Parasit. Hung. 19: 31-42.
- Lim, L. H. S., 1989. *Eutrianchoratus* species (Heterochocleidinae, Monogenea) from a Malaysian freshwater fish, *Belontia hasselti* (Anabantoidei). Helminthologia, 26: 249-258.
- Lom, J and G.L. Hoffman., 1971. Morphology of the spores of *Myxosoma cerebralis* (Hofer, 1903) and *Myxosoma cartilaginis* (Hoffman, Putz and Dunbar, 1965). J. Parasitol., 57: 1302-1308.
- Lom, J., I. Dykova, M. Pavlaskova and G. Grupcheva, 1983. *Sphaerospora molnari* sp. nov. (Myxozoa: Myxosporea), an agent of gills, skin and blood sphaerosporosis of common carp in Europe. Parasitol., 86: 529-535.
- Lom, J. and I. Dykova, 1986. Comments on myxosporean life cycles. Symposia Biol. Hung., 33: 309-318.
- Lom, J and R. Arthur., 1989. A guideline for the preparation of species descriptions in Myxosporea. J. Fish Dis., 12: 151-156.
- Lom, J. and I. Dykova, 1992. Protozoan Parasites of Fishes. Elsevier, Amsterdam, London, New York, Tokyo.
- Malmberg, G., 1970. The excretory systems and the marginal hooks as a basis for the systematics of *Gyrodactylus* (Trematoda, Monogenea). Archiv. Zool., 23: 235 pp.

- McCraren, J.P., M.L. Landolt., G.L. Hoffman and F.P. Meyer., 1975. Variation in response of channel catfish to *Hennegua* sp. infections (Protozoa: Myxosporidea). J. Wildl. Dis., 11: 2-7.
- Modin, J.C., 1981. *Microsporidium rhabdophilia* n. sp. from the rodlet cells of salmonid fishes. J. Fish Dis., 4: 203-211.
- Molnar, K., 1971. Studies on gill parasitosis of the grass carp (*Ctenopharyngodon idella*) caused by *Dactylogyrus lamellatus* Achmerov, 1952. II. Epizootiology. Acta Vet. Acad. Scient. Hungar., 21: 361-375.
- Molnar, K., 1972. Studies on gill parasitosis of the grass carp (*Ctenopharyngodon idella*) caused by *Dactylogyrus lamellatus* Achmerov, 1952. IV. Histopathological changes. Acta Vet. Acad. Scient. Hungar., 22: 9-24.
- Molnar, K., G. Csaba and E. Kovacs-Geyer, 1986. Study on the postulated identity of *Hoferellus cyprini* (Doflein, 1898) and *Mitraspora cyprini* Fujita, 1912. Act. Vet. Hungar., 34: 175-181.
- Molnar, K. and E. Kovacs-Geyer, 1986. Experimental induction of *Sphaerospora renicola* (Myxosporidea) infection in common carp (*Cyprinus carpio*) by transmission of SB- protozoans. Appl. Ichth., 2: 86-94.
- Molnar, K., 1993. Recent achievements in the chemotherapy of myxosporidian infections of fish. Act. Veterinaria Hungarica, 41: 51-58.
- Morrison, C.M. and V. Sprague, 1981. Microsporidian parasites in the gills of salmonid fishes. J. Fish Dis., 4: 203-211.
- Natividad, J.M., M.G. Bondad-Reantaso and J.R. Arthur., 1986. Parasites of Nile Tilapia (*Oreochromis niloticus*) in the Philippines. In: Maclean, L.J., L.B. Dizon and L.V. Hosillos, (Eds.), The First Asian Fisheries Forum. Asian Fisheries Society, Manila, Philippines, pp: 255-259.
- Nigrelli, R.F. and G.M. Smith, 1938. Tissue response of *Cyprinodon variegatus* to the myxosporidian parasite, *Myxobolus lintoni* Gurley. Zool., 23: 195-202 + 7 plates.
- Obiakezie, A.I. and M. Taege, 1991. Mortality in hatchery reared fry of the African catfish *Clarias gariepinus* (Burchell) caused by *Gyrodactylus groschaffi* Ergens, 1973. Bull. Eur. Ass. Fish Pathol. 11: 82-85.
- Ogawa, K., K.P. Delgahapitiya, T. Furyta and H. Wakabayashi, 1992. Histological studies on the host response to *Myxobolus artus* Akhmerov, 1960 (Myxozoa, Myxobolidae) infection in the skeletal muscles of carp, *Cyprinus carpio* L. J. Fish Biol., 41: 363-371.
- Oliver, G., 1977. Effect pathogene de la fixation de *Diplectanum aequans* (Wagener, 1857) Diesing 1858 (Monogenea, Monopistocotylea, Diplectanidae) sur les branchies de *Dicentrarchus labrax* Linneus, 1758), (Pisces, Serranidae). Zeit. Parasitenkunde., 53: 7-11.
- Paperna, I., 1963a. Some observations on the biology of *Dactylogyrus vastator* in Israel. Bamidgeh. Bull. Fish Cult. Israel, 15: 8-28.
- Paperna, I., 1963b. Dynamics of *Dactylogyrus vastator* Nybelin (Monogenea) populations on the gills of carp fry in fish ponds. Bamidgeh. Bull. Fish Cult. Israel, 15: 31-50.
- Paperna, I., 1963c. *Enterogyrus cichlidarum* gen. n. sp. n., a monogenetic trematode parasitic in the intestine of fish. Bull. Res. Council. Israel, 118: 183-187.
- Paperna, I., 1963d. Monogenetic trematodes from inland water fishes. Ph.D. Thesis, Submitted to the Hebrew University of Jerusalem (Hebrew Text, English summary), Jerusalem.
- Paperna, I., 1964a. The metazoan parasite fauna of Israel inland water fishes. Bamidgeh. Bull. Fish Cult. Israel, 16: 3-66.
- Paperna, I., 1964b. Parasitic helminths of inland-water fishes in Israel. Israel J. Zool., 13: 1-20.
- Paperna, I., 1964c. Host reaction to infestation of carp with *Dactylogyrus vastator* Nybelin, 1924 (Monogenea). Bamidgeh. Bull. Fish Cult. Israel, 16: 129-141.
- Paperna, I., 1964d. Adaptation of *Dactylogyrus extensus* (Mueller and Van Cleave, 1932) to ecological conditions of artificial ponds in Israel. J. Parasitol., 50: 90-93.
- Paperna, I., 1968a. *Onchobdella* n. gen., new genus of monogenetic trematodes (Dactylogyridae, Bychowski, 1933) from cichlid fish from West Africa. Proc. Helm. Soc. Wash., 35: 200-206.
- Paperna, I., 1968b. Ectoparasitic infections of fish of Volta Lake, Ghana. Bull. Wild. Dis. Ass., 4: 135-137.
- Paperna, I. and J.P. Thurston, 1968. Report on ectoparasitic infections of freshwater fish in Africa. Bull. Off. Int. Epizoot., 69: 1192-1206.
- Paperna, I., 1969. Monogenea of the subfamily Heteronchocleidinae, Price, 1968 (Dactylogyridae) from African freshwater fish. Parasitol., 59: 557-561.
- Paperna, I., 1973. Occurrence of Cnidospora infections in freshwater fishes in Africa. Bull. Inst. Fond Afr. Noir, 35(A-3): 509-521.
- Paperna, I., 1979. Monogenea of inland water fish in Africa. Annal. Mus. Roy. D'AFR. Cent. Tervurn Belg., Ser. IN-8 Science Zool., 226: 131, 38 plates.
- Paperna, I. A., H. Hartley and R.H.M. Cross, 1987. Ultrastructural studies on the plasmodium of *Myxidium giardi* (Myxosporidea) and its attachment to the epithelium of the urinary bladder. Int. J. Parasitol., 17: 813-819.

- Paperna, I., 1980. Parasites, Infections and Diseases of Fish in Africa. CIFA Tech. Pap. 7: 216.
- Paperna, I. and R.M. Overstreet, 1981. Parasites and diseases of Mulletts (Mugilidae). In: Oren, O.H., (Ed.), Aquaculture of Grey Mulletts. IBP 26, Cambridge University Press, U.K.
- Paperna, I., J.G. Van As and L. Basson, 1984. Review of diseases affecting cultured cichlids. In: Fishelson, L. & Yaron, Z. (eds.) Internat. Symp. on Tilapia Aquaculture, Tel Aviv University Press, Country, pp: 174-184.
- Paperna, I., 1991. Diseases caused by parasites in the aquaculture of warm water fish. Annual Rev. Fish Dis. 1: 155-194.
- Prost, M., 1963. Investigation on the development and pathogenicity of *Dactylogyrus anchoratus* (Duj. 1845) and *D. extensus* Mueller et Van Cleave, 1932 for breeding carps. Act. Parasitol. Polonica, 11: 17-48.
- Putz, R.E. and J.J.A. McLaughlin, 1970. Biology of Nosematidae (Microsporidia) from fresh water and euryhaline fishes: A symposium on diseases of fishes and shellfish. Amer. Fish. Soc. Wash. Special Pub., 5: 124-132.
- Roberts, R.J and C. Sommerville., 1982. Diseases of tilapias. In: Pullin, R.S.V. and R.H. Lowe-McConnell, (Eds.), The Biology and Culture of Tilapias. ICLARM Conference Proceedings, 7, Manila, Philippines, pp: 247-263.
- Rukyani, A., 1990. Histopathological changes in the gills of common carp (*Cyprinus carpio*) infected with the myxosporean parasite *Myxobolus koi*, Kudo, 1920. Asian Fish Sci., 3: 337-341.
- Schulman, S.S., 1966. Myxosporea of the Fauna of the USSR (in Russian). Nauka, Moscow, pp: 504.
- Sakiti, N.G. and G. Bouix, 1987. *Nosemoides tilapiae* n. sp., microsporidie parasite de poissons Cichlidae des eaux saumâtres du Benin: implantation et caracteres ultrastructuraux. Parasitol. Res., 73: 203-212.
- Sarig, S., 1971. The prevention and treatment of diseases of warm water fish under subtropical conditions, with special emphasis on intensive fish farming. T.F.H. Publications Inc., Jersey City, N.J., pp: 127.
- Sarig, S., M. Lahav and M. Shilo, 1965. Control of *Dactylogyrus vastator* on carp fingerlings with dipterex. Bamidgheh Bull. Fish Cult. Israel, 14: 47-52.
- Schmahl, G. and H. Mehlhorn, 1985. Treatment of fish parasites 1. Praziquantel effective against Monogenea (*Dactylogyrus vastator*, *Dactylogyrus extensus*, *Diplozoon paradoxum*). Z. Parasitenk., 71: 727-737.
- Schmahl, G. and H. Mehlhorn, 1989. Treatment of fish parasites 6. Effects of Sym. Triazinone (Toltrazuril) on developmental stages of *Glugea anomala*, Moniez, 1887 (Microsporidia): A light and electron microscopic study. Europ. J. Protistol., 24: 252-259.
- Schmahl, G., 1991. The chemotherapy of monogeneans which parasitize fish: a review. Folia Parasitol., 38: 97-106.
- Shaharom-Harrison, F., 1986. The Reproductive Biology of *Dactylogyrus nobilis* (Monogenea: Dactylogyridae) from the Gills of Big Head Carp (*Aristichthys nobilis*). In: Maclean, J.L., L.B. Dizon and L.V. Hosillos, (Eds.), The First Asian Fisheries Forum. Asian Fisheries Society, Manila, Philippines, pp: 265-268.
- Shaharom-Harrison, F., 1987. The effect of hydrocortisone on *Cichlidogyrus* infection on *Tilapia* under controlled conditions. Tropical Biomed., 4: 196-198.
- Sitja-Bobadilla, A. and P. Alvares-Pelleteiro, 1992. Effect of Fumagillin treatments on sea bass *Dicentrarchus labrax* parasitized by *Sphaerospora testicularis* (Myxosporea: Bivalvulida). Dis. Aquat. Org., 14: 171-178.
- Szekely, C., K. Molnar and F. Baska, 1988. Efficacy of fumagillin against *Myxidium giardi* Cepede, 1906 infection of the European eel (*Anguilla anguilla*): New observations of myxidiosis of imported glass eels. Act. Vet. Hungar., 36: 239-246.
- Thurnbull, E.R., 1956. *Gyrodactylus bullatardis* n. sp. from *Lebistes reticulatus* Peters with a study of its life cycle. Can. J. Zool., 34: 583-594.
- Thurston, J.P and I. Paperna, 1969. *Diplectanum lacustris* sp. Nov. (Dactylogyroidea: Diplectanidae) a monogenetic trematode from the gills of the Nile perch. Proc. Helm. Soc. Wash., 36: 214-218.
- Tripathi, Y.R., 1957. Monogenetic trematodes from fishes of India. Indian J. Helminth., 9: 1-149.
- Van Wyk, G.F., 1968. Annual report No. 24, 1967. Jokershoek Hatchery, Division of Inland Fisheries, Department of Nature Conservation, Province of Good Hope, Republic of South Africa.
- Walliker, D., 1968. The nature of the iodophilous vacuole of myxosporidian spores, and a proposal to synonymize the genus *Myxosoma* Thelohan, 1892 with the genus *Myxobolus* Butschli, 1882. J. Protozool., 15: 571-575.
- Wolf, K. and E. Markiw, 1984. Biology contravenes taxonomy in Myxozoa: new discoveries show alternation of invertebrate and vertebrate hosts. Sci., 225: 1449-1452.
- Weiser, J., 1985. Phylum Microspora Sprague, 1969. In: Lee et al., (Eds.), Illustrated guide to protozoa. Society of Protozoologists, Country, pp: 375-383.
- Yokoyama, H., K. Ogawa and H. Wakabayashi, 1990. Chemotherapy with fumagillin and toltrazuril against kidney enlargement disease of goldfish caused by the myxosporean *Hofferellus carassii*. Fish Pathol., 25: 157-163.
- Yokoyama, H., K. Ogawa and H. Wakabayashi, 1991. A new collection method of Actinosporeans-a probable infective stage of Myxosporeans to fishes-from tubificids and experimental infection of goldfish with the Actinosporean, *Raabeia* sp. Gyobyu Kenkyu, 26: 133-138.